

The ESIM Model

ESIM (European Simulation Model), the model used for the analysis, is a SuperCalc-5 spreadsheet-based, multi-commodity, multi-regional, comparative-static, net-trade, partial-equilibrium policy model. This study focused on accurately modeling the agricultural and policy environment of the EU-12 and incorporating new and potential entrants.

ESIM contains 13 countries/regions and reproduces total world production and trade of the modeled commodities (table 1). Since the purpose of this study is to examine the effects of EU enlargement, detailed country and regional coverage is provided for the European countries now in the EU as well as potential entrants.

Commodity coverage is very extensive. The model contains 28, mostly temperate zone, agricultural products (table 2), mostly commodities that have received substantial support from the EU. Two are of special interest to the feed sector of the EU (and to U.S. exporters)—manioc (or cassava) and corn gluten feed.

The policy-driven model contains an extensive list of policy instruments that are used or could be used in the future by either the EU or potential entrants (table 3). Included in the model are commodity-specific policies (in 12 different categories), policies that affect all commodities, and non-commodity-specific exogenous variables such as the exchange rate and population and income growth rates. The modeling block representing the United States incorporates the major U.S. policies (before passage of the 1996 Farm Act) but these policies are not varied by scenario. The model is designed to run in a large-country mode where world prices are endogenous. Policy changes in the EU, a major producer, consumer, and trader of the commodities analyzed here, and EU enlargement are expected to affect world prices. Equilibrium in the large-country mode is attained when world prices adjust to the point where world net trade is zero for each year of the simulation.

The model can also be used in a small-country mode based on the assumption that world prices are exogenous. Under this assumption, one can examine the implications of domestic policy or production/demand

Table 1—Countries and/or regions in ESIM

EU-12 (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom)
Austria
Finland
Norway
Sweden
Switzerland
Czech Republic and Slovakia (treated as one economy)
Hungary
Poland
United States
Other industrial countries
Former centrally planned economies (excluding those above)
Rest of world

conditions without feedback from world prices. The model was used in the small-country mode in ERS's baseline where world prices are given exogenously; the EU response to those prices is determined in that exercise.

The equations for the countries/regions are included in a single spreadsheet. Each country/region module in the model contains:

- 1) a policy block with parameters for the relevant policy instruments and the exogenous non-commodity-specific variables;
- 2) a behavioral equation block describing production, consumption, net trade, and domestic prices;
- 3) a financial calculation block where farm receipts and budget expenditures are calculated; and
- 4) an extensive parameter block (table 4).

Each country/region has an associated data file that contains time series data⁴ on production, consumption, prices, and policy parameters for each of the modeled commodities. These data are used to initialize the model. The initialized or base model thus reproduces whichever year or average of years the

⁴ Data were obtained from USDA's electronic PS&D data base.

Table 2—Commodities in ESIM

Crops
Wheat: common wheat, durum wheat
Coarse grains: barley, corn, other coarse grains
Rice
Sugar
Oilseeds and products
Soybeans (meal and oil)
Rapeseed (meal and oil)
Sunflower (meal and oil)
Dairy
Fluid milk
Cheese
Butter
Skim milk powder
Livestock
Beef and veal
Pork
Poultry
Eggs
Other
Manioc
Corn gluten feed
Other energy feeds
Other protein feeds

analyst thinks is representative for the analysis. This method of model initialization allows the analyst flexibility in choosing the appropriate base year to reproduce. Updating the model to a new base year as new data are collected is relatively easy. The results presented in this analysis for the EU-12 are based on a model calibrated with data averaged for the 1989-91 period.

Behavioral Equations

The model contains behavioral equations for production, human demand, and feed demand for each commodity in each country/region. Net trade is the balance of production and total use.⁵ A two-way interaction through feeding links the crop and livestock sectors: demand for feed by the livestock sector affects crop prices and crop production, while crop prices

⁵ As the model is used to analyze the longer-run implications of alternative policies, stock changes are not included in the model.

Table 3—Policy parameters in ESIM

Commodity specific
Compensation payments
Deficiency payments
Export subsidies
Producer subsidies
Consumer subsidies
Input subsidies
Tariffs
Intervention price
Threshold price
Target price
Target trade
Production quotas
Non-commodity specific
Set-aside rate
Area slippage
Small producer share of cereal/oilseed area
Exogenous variables
Exchange rate
Income growth rate
Population growth rate

affect feeding costs, which help determine levels of livestock production.

ESIM is not a structural model, but an analytical framework where the behavior of economic agents is represented, in reduced form, by elasticity parameters that reflect adjustments to changing prices. The elasticity parameters were derived from a variety of sources. For the Eastern European and EFTA countries, they represent our best assessment following literature review and discussions with regional experts. Feed demand elasticities for the EU were provided by Jan Blom of Agricultural Economics Research Institute (LEI-DLO), the Netherlands, as a result of a cooperative agreement with ERS; area elasticities were generated by Martin Johnson, formerly with ERS; the remaining elasticities were obtained from ERS's US-EC Model. The elasticity parameters are assumed constant throughout the period of analysis, and behavior is modeled using double-logarithmic functional forms. The model is specified in real terms because all prices and exchange rates are deflated by the CPI.

Table 4—ESIM schematic

	Policy block	Behavioral equations	Budget block	Parameters
Country 1:				
Commodity 1				
Commodity 2	Policy 1, policy 2...	Production, trade, demand	Export refunds, etc.	Elasticities
Country 2:				
Commodity 1				
Commodity 2	Policy 1, policy 2...	Production, trade, demand	Export refunds, etc.	Elasticities
Country n:				
Commodity 1	Policy 1, policy 2...	Production, trade, demand	Export refunds, etc.	Elasticities
Commodity 2				

The behavioral equations described are specific to the EU and new entrants upon entering the EU. Equation specification and policy parameters reflect the 1992 CAP reform, but do not include GATT commitments as binding constraints on EC policies, since one objective is to estimate the need for policy changes to meet these commitments.

Specification of Crop Production

Crop production is calculated as the product of area harvested times yield for the crops in all countries/regions of the model. Area harvested is a function of relative prices, while yield is a function of price and a technological growth rate based on recent historical trends and interviews with EU farmers.

For the EU, particularly because of CAP reform, area harvested for grains and oilseeds is not only a function of prices, but also a function of policy parameters. CAP reform reduced policy prices but provided compensatory payments to producers of grains, oilseeds, and protein crops; however, large producers (those with production above 92 tons) have to set aside a portion of their land in order to receive compensation payments for the price cuts. Thus, the model calculates the amount of area set aside for each of the relevant crops and the area harvested.

The sequence for calculating area harvested in the model is:

- 1) determine the desired area for each grain/oilseed crop based on relative prices and relative compen-

sation payments, assuming set aside area is not relevant;

- 2) adjust area allocation for grains to take into account small producers who do not have to set-aside land (we assume that oilseeds are produced only by large producers);
- 3) calculate set aside area for each of the grains and oilseed crops based on announced policy about the set-aside rate and adjustments for small producers and slippage; and
- 4) calculate actual area harvested for each crop as the difference between the desired area harvested and the area that is set aside.

Based on the description above, actual area harvested is a function of relative prices, compensation payments, and the set-aside rate. In reduced form, area harvested for grains/oilseeds can be represented as:

$$Ah_i = f(P_1, \dots, P_n, C_g, C_o, SAR, AS, SF)$$

where:

P_n = own and cross prices, 1,...,n includes common wheat, durum, corn, barley, other coarse grains, soybeans, rapeseed, and sunflower seed;

C_g = grain compensation payments;

C_o = oilseed compensation payments;

SAR = announced set-aside rate;

AS = area slippage rate; and

SF = small producer adjustment.

Matrices of price elasticities reflect homogeneity and symmetry requirements. Compensation payments are

assumed partially decoupled so they do not affect yield in the model although they do affect acreage, but the requirement to set aside land is assumed to affect yield. Yield per hectare of grains/oilseeds is:

$$Y_i = f(P_i, YS_i, T, SA)$$

where:

Y_i = yield per hectare of grain/oilseed i ;

P_i = price of grain/oilseed i ;

YS_i = yield slippage factor for grain/oilseed i ;

T = productivity growth factor representing technological change; and

SA = set-aside area of grain/oilseed i .

Total demand for each crop product consists of three separable components: human demand, feed demand, and demand for seed. Feed and human demand are described more fully below. Seed demand is simply modeled as a function of harvested area. For oilseeds, demand is for crushing the seed into meal and oil; this crush demand is a function of relative oilseed prices and crush margins. Meal and oil are modeled as joint products with fixed coefficients, meaning a constant crush or extraction rate per unit of seed crushed.

Feed Demand

In modeling feed demand, the Organization for Economic Cooperation and Development's (OECD) Multilateral Trade Model (MTM) modeling approach was followed by specifying a separate feed-demand elasticity matrix for each livestock category.⁶ Given prices, production of a unit of each livestock product is assumed to require a certain amount of each type of feed. These feed rates are not technical feed requirements, but are derived from a feed-utilization matrix and represent experts' assessment of how total feed demand for any particular feed ingredient is allocated across livestock products. Each feed rate is further assumed a function of relative prices as follows:

$$FR_i^j = f(P_1, \dots, P_K)$$

where:

FR_i^j = feed rate for feed input i going to livestock j ;
and

P_1, \dots, P_K = prices of feed inputs ($k = 12$).

Livestock prices are not a factor in determining feed rates. Expansion or contraction of livestock production, although affecting total feed demand, does not affect feed per unit of output, whereas a change in relative feed prices does affect the feed rate. Feed prices influence livestock production in the model through feed costs per unit of livestock production.

Twelve feed ingredients are included in the model, so each livestock category contains a 12 x 12 elasticity matrix, resulting in 144 elasticity parameters for each livestock product. Since 5 livestock categories were included in the model, a total of 720 feed-demand elasticity parameters were required. Some elasticity parameters are zero because not all feed ingredients are fed to each livestock category. In addition, symmetry and homogeneity are imposed, which reduces the number of elasticity parameters needed.

Total feed demand for feed ingredient i is:

$$TF_i = \sum_j (FR_i^j * Lv_j)$$

where:

TF_i = total feed demand for feed ingredient i ;

FR_i^j = feed rate for feed input i going to livestock j ;
and

Lv_j = production of livestock j .

Livestock Production

In the livestock sector, production is a function of the relative prices of livestock commodities, feed costs, and exogenous technological growth rates as follows:

$$Lv_j = f(P_1, \dots, P_k, FC_j, T)$$

where:

Lv_j = production of livestock j ($j = 1, 2, \dots, 5$);

P_1, \dots, P_k = prices of livestock commodities;

FC_j = feed cost of livestock j ; and

T = productivity growth factor representing disembodied technological change.

⁶ For a general description of the MTM model, see OECD, *National Policies and Agricultural Trade*, Paris, 1987, pp. 136-185. The feed demand component used in the MTM model and assumed elasticities are described in more detail in OECD document DAA/1926-TD/85.262, Paris, September 17, 1985.

Feed cost per unit for each livestock commodity is a function of feed rates and feed prices as follows:

$$FC_j = \sum_i (FR_i^j * P_i)$$

where:

FC_j = cost index of feeding livestock j ;

FR_i^j = feed rate for feed input i going to livestock j ;
and

P_i = price of feed ingredient i ($i = 1, 2, \dots, 12$).

Interactions between the crop and livestock sectors are achieved through feed-demand and feeding-rate relations. Feed prices affect not only the composition of the feed mix, but also the production of livestock products. Thus, not only are the substitution and complementary effects of changing relative prices and shifts among feed ingredients represented in the model, but the expansion or contraction effects on the livestock sector are also captured by changing feed costs.

Consumption Demand

Human demand for goods is a function of relative product prices, population, and income:

$$D_i = f(P_1, P_2, \dots, P_m, \text{Pop.}, \text{Inc.})$$

where:

D_i = demand for product i ;

P_1, \dots, P_m = own and cross prices of goods;

Pop. = population growth rate; and

Inc. = income growth rate.

Matrices of price and income elasticities reflect homogeneity and symmetry requirements. For each commodity in the model, net trade is the difference between production and total demand:

$$NT_i = PROD_i - TD_i$$

where:

NT_i = net trade;

$PROD_i$ = production (area times yield); and

TD_i = total demand (feed plus human plus seed).

In addition to determining production, consumption, and net trade, the model calculates the financial implications of various policy options, with a focus on calculating financial returns to growers through market operations (farm receipts) and the public budget implications of export refunds and compensation payments.

Policy analysis is undertaken by changing the policy block described above. The policy block for any country/region or group of countries/regions can be changed directly in the model file (if the model is run for only 1 year), or one can use the special programming file which contains the macro and policy data files to perform policy analysis (if the model is run for a sequence of years). A set of policy files with policy assumptions up to the year 2005 was developed for each of the 5 EFTA countries, each of the 4 CEEC countries, and for the EU-12. Special programming macro files simulated the model for a sequence of years (up to 2005) or for any one year of interest.⁷

Policy files for the EU accession candidates were prepared so that both the year of accession and the period during which candidates' policies are aligned with those of the EU can be specified. Accessing countries' decisions on adoption of production quotas (for milk and sugar), compensation payments, and set aside may also be specified in the model.

The rest of the report presents the results of the various scenarios described above, organized to highlight the effects of the various scenarios on the EU-12 and on the accession candidates.

⁷ The model is available from the authors upon request.